

## CLAIMS

1. A differential pressure type flowmeter comprising an orifice, a detector to detect a fluid pressure  $P_1$  on the upstream side of an orifice, a detector to detect a fluid pressure  $P_2$  on the downstream side of an orifice, a detector to detect a fluid temperature on the upstream side of an orifice, and a control computation circuit to compute a fluid's flow rate passing through an orifice with the pressure  $P_1$ ,  
wherein pressure  $P_2$  and temperature  $T$  are detected by the aforementioned detectors, and the aforementioned fluid's flow rate  $Q$  is computed with an equation  $Q = C_1 \cdot P_1 \sqrt{T} \cdot ((P_2/P_1)^m - (P_2/P_1)^n)^{1/2}$  (where  $C_1$  is a proportional constant, and  $m$  and  $n$  are constants).
2. A differential pressure type flowmeter comprising an orifice, a detector to detect a fluid pressure  $P_1$  on the upstream side of an orifice, a detector to detect a fluid pressure  $P_2$  on the downstream side of an orifice, a detector to detect a fluid temperature  $T$  on the upstream side of an orifice, and a control computation circuit to compute a fluid's flow rate  $Q$  passing through an orifice with the pressure  $P_1$  and pressure  $P_2$  and temperature  $T$  detected by the aforementioned detectors,  
wherein the aforementioned control computation circuit is installed with a flow rate computation circuit wherewith an equation  $Q = C_1 \cdot P_1 \sqrt{T} \cdot ((P_2/P_1)^m - (P_2/P_1)^n)^{1/2}$  (where  $C_1$  is a proportional constant, and  $m$  and  $n$  are constant), and further comprising a correction data memory circuit wherein changes in the pressure  $P_2$  on the downstream side of an orifice

obtained by actual measurements beforehand and flow rate errors of the aforementioned fluid's flow rate  $Q$  are storable, and a flow rate correction computation circuit to correct the aforementioned computed fluid's flow rate with the correction data from the correction data memory circuit, thus the computed fluid's flow rate  $Q$  being corrected depending on changes of a pressure  $P_2$  on the downstream side of an orifice, to output a corrected flow rate value  $Q$ .

3. A differential pressure type flowmeter as claimed in Claim 2 wherein said control computation circuit further comprises a pressure ratio computation circuit to compute a ratio of a fluid pressure  $P_1$  on the upstream side of an orifice and a fluid pressure  $P_2$  on the downstream side of an orifice; a critical condition judgment circuit to judge a state of a fluid by comparing the aforementioned computed pressure ratio and a fluid's critical pressure ratio; and a No.2 flow rate computation circuit to compute a fluid's flow rate  $Q$  by using the equation  $Q=KP_1$  (where  $K$  is a proportional constant) when the fluid is under critical conditions, thus outputting a fluid's flow rate  $Q$  computed with the aforementioned No.2 flow rate computation circuit when the fluid is under critical conditions, and also outputting a fluid's flow rate value  $Q'$  corrected with the flow rate correction computation circuit when the fluid is under non-critical conditions.
4. A differential pressure type flowmeter characterized in that flow rate measurements can be performed with high accuracy over a wide flow rate range by combining a differential pressure type flowmeter for measuring a flow rate range of 100%-10% of the maximum flow rate range and a

differential pressure type flowmeter for measuring a flow rate range of 10%-1% of the maximum flow rate range and by switching a fluid to be measured in accordance with the aforementioned flow rate ranges using a switching valve, to supply the fluid to the differential pressure type flowmeters according to claims 1 - 3.

5. A differential pressure type flowmeter as claimed in Claim 4 wherein each said differential pressure type flowmeter comprises a orifice, a detector to detect a fluid pressure  $P_1$  on the upstream side of an orifice, a detector to detect a fluid pressure  $P_2$  on the downstream side of an orifice, a detector to detect a fluid temperature  $T$  on the upstream side of an orifice, and a control computation circuit to compute a fluid's flow rate by using the pressure  $P_1$ , pressure  $P_2$ , and temperature  $T$  detected by the aforementioned detectors, and the aforementioned fluid's flow rate  $Q$  is computed with the equation  $Q = C_1 \cdot P_1 \sqrt{T} \cdot ((P_2/P_1)^m - (P_2/P_1)^n)^{1/2}$  (where  $C_1$  is a proportional constant, and  $m$  and  $n$  are constants).
6. A differential pressure type flowmeter as claimed in Claim 4 wherein each said differential pressure type flowmeter comprises an orifice, a detector to detect a fluid pressure  $P_1$  on the upstream side of an orifice, a detector to detect a fluid pressure  $P_2$  on the downstream side of an orifice, a detector to detect a fluid temperature  $T$  on the upstream side of an orifice, and a control computation circuit to compute a fluid's flow rate by using the pressure  $P_1$ , pressure  $P_2$ , and temperature  $T$  detected by the aforementioned detectors; and the aforementioned control computation circuit is equipped with a flow rate computation circuit wherewith a fluid's

flow rate  $Q$  is computed with the equation  $Q = C_1 \cdot P_1 \sqrt{T} \cdot ((P_2/P_1)^m - (P_2/P_1)^n)^{1/2}$  (where  $C_1$  is a proportional constant, and  $m$  and  $n$  are constants), and further comprising a correction data memory circuit wherein changes of a pressure  $P_2$  on the downstream side of an orifice obtained by actual measurements beforehand and flow rate errors of the aforementioned fluid's flow rate  $Q$  is storable, and a flow rate correction computation circuit to correct the aforementioned computed fluid's flow rate  $Q$  with the correction data from the correction data memory circuit, thus computed fluid's flow rate  $Q$  being corrected depending on changes of a pressure  $P_2$  on the downstream side of an orifice to output a corrected flow rate  $Q'$ .

7. A differential pressure type flowmeter characterized by that it is so constituted that by forming it with a valve body 12 provided with a fluid inlet a, a fluid outlet b, a mounting hole 17a for the No.1 switching valve 10, a mounting hole 17b for the No.2 switching valve 11, a mounting hole 18a for a fluid pressure detector 2 on the upstream side of an orifice, a mounting hole 18b for a fluid pressure detector 3 on the downstream side of an orifice, a mounting hole for a fluid temperature detector 4 on the upstream side of an orifice, fluid passages 16a, 16b and 16e for directly passing through a fluid inlet, the undersides of a mounting hole 17a for the No.1 switching valve 10, a mounting hole 18a for a fluid pressure detector 2 on the upstream side of an orifice and a mounting hole 17b for the No.2 switching valve 11 which are made in the interior of the aforementioned valve body 12, a fluid passage 16f for communication of

the underside of a mounting hole 17a for the No.1 switching valve and the underside of a mounting hole 17b for the No.2 switching valve 11, a fluid passage 16c for communication of the underside of a mounting hole 17b for the No.2 switching valve 11 and the underside of a mounting hole 18b for the fluid pressure detector 3 on the downstream side of an orifice, a fluid passage 16d for communication of the underside of a mounting hole 18b for the pressure detector 3 on the downstream side of an orifice and a fluid outlet b, a fluid pressure detector 2 on the upstream side of an orifice and a fluid pressure detector 3 fixed to the aforementioned mounting holes 18a and 18b respectively, a fluid temperature detector 4 on the upstream side of an orifice, the No.1 switching valve 10 wherewith opening and closing are conducted between the aforementioned fluid passage 16e and fluid passage 16f, the No.2 switching valve 11 wherewith opening and closing are conducted between the aforementioned fluid passage 16b and fluid passage 16c, an orifice 1' for a small flow quantity installed halfway to the aforementioned fluid passage 16f, an orifice 1" for a large flow quantity installed on the aforementioned fluid passage 16a or fluid passage 16b, and a control computation circuit to compute a fluid's flow rate Q passing through an orifice 1' for a small flow quantity and an orifice 1" for a large flow quantity depending on the pressure P<sub>1</sub>, pressure P<sub>2</sub> and temperature T detected by the aforementioned pressure detectors 2 and 3 and temperature detector 4, respectively, by using the equation  $Q = C_1 \cdot P_1 / \sqrt{T} \cdot ((P_2/P_1)^m - (P_2/P_1)^n)^{1/2}$ , thus making it possible that a flow rate in a large flow quantity

range is measured by closing the aforementioned No.1 switching valve 10 and opening No.2 switching valve 11, while a flow rate in a small quantity range is measured by opening the aforementioned No.1 switching valve 10 and closing the No.2 switching valve 11.

8. A differential pressure type flowmeter as claimed in Claim 4 or Claim 7 wherein it is so constituted that either one of the No.1 switching valve 10 or No.2 switching valve 11 is made to be a normal/close type valve and the other a normal/open type valve, and operating fluid is supplied from one control electromagnetic valve Mv to driving cylinders 10a and 10b of both switching valves.
9. A differential pressure type flowmeter as claimed in Claim 7 wherein it is so made that a flow rate range up to 100%-10% of the maximum flow rate is measured by closing the No.1 switching valve 10 and opening the No.2 switching valve 11, while a flow rate up to 10%-1% of the maximum flow rate is measured by opening the No.1 switching valve 10 and closing the No.2 switching valve 11.
10. A differential pressure type flowmeter as claimed in Claim 7 or Claim 8 further comprising a pressure detector 2 to detect a pressure on the upstream side of an orifice, a pressure detector 3 to detect a pressure on the downstream side of an orifice, and a temperature detector to detect a temperature on the upstream side of an orifice, are made sharable with both differential pressure type flowmeters.
11. A differential pressure type flow controller comprising a control valve part equipped with a valve driving part, an orifice installed on the downstream

side thereof, a detector to detect a fluid pressure  $P_1$  on the upstream side of an orifice, a detector to detect a fluid pressure  $P_2$  on the downstream side of an orifice, a detector to detect a fluid temperature  $T$  on the upstream side of an orifice, and a control computation circuit equipped with a flow rate comparison circuit wherewith a fluid's flow rate  $Q$  passing through an orifice is computed by using the pressure  $P_1$ , pressure  $P_2$  and temperature  $T$  detected by the aforementioned detectors, and the difference between a computed flow rate  $Q$  and a set flow rate  $Q_s$  is computed, the aforementioned fluid's flow rate  $Q$  is computed by the equation  $Q = C_1 \cdot P_1 / \sqrt{T} \cdot ((P_2/P_1)^m - (P_2/P_1)^n)^{1/2}$  (where  $C_1$  is a proportional constant, and  $m$  and  $n$  are constants).

12. A differential pressure type flow controller comprising a control valve part equipped with a valve driving part, an orifice installed on the downstream side thereof, a detector to detect a fluid pressure  $P_1$  on the upstream side of an orifice, a detector to detect a pressure  $P_2$  on the downstream side of an orifice, a detector to detect a temperature  $T$  on the upstream side of an orifice, and a control computation circuit equipped with a flow rate comparison circuit wherewith the fluid's flow rate  $Q$  is computed by using the pressure  $P_1$ , pressure  $P_2$  and temperature  $T$  detected by the aforementioned detectors, and the difference between a computed flow rate  $Q$  and a set flow rate  $Q_s$  is computed, and the aforementioned control computation circuit is equipped with a flow rate computation circuit wherewith a fluid's flow rate  $Q$  is computed by the equation  $Q = C_1 \cdot P \sqrt{T} \cdot ((P_2/P_1)^m \cdot (P_2/P_1)^n)^{1/2}$  (where  $C_1$  is a proportional constant, and  $m$  and  $n$

are constants), and further comprising a correction data memory circuit wherein changes of the pressure  $P_2$  on the downstream side of an orifice obtained by actual measurements beforehand and flow rate errors of the aforementioned fluid's flow rate  $Q$  are storable, a flow rate correction computation circuit to correct the aforementioned computed fluid's flow rate  $Q$  with the correction data from the correction data memory circuit, thus a fluid's flow rate  $Q$  being corrected depending on the changes of a pressure  $P_2$  on the downstream side of an orifice, and the corrected flow rate value  $Q$  being inputted to the aforementioned flow rate comparison circuit to compute the difference of the flow rates  $\Delta Q = Q' - Q_s$ .

13. A differential pressure type flow controller as claimed in Claim 12 wherein the control computation circuit further comprises a pressure ratio computation circuit to compute the ratio of a fluid pressure  $P_1$  on the upstream side of an orifice and a fluid pressure  $P_2$  on the downstream side of an orifice, a critical conditions judgment circuit to judge a state of a fluid by comparing the aforementioned computed pressure ratio and a fluid's critical pressure ratio, and a No.2 flow rate computation circuit to compute a fluid's flow rate  $Q$  by using the equation  $Q = KP_1$  (where  $K$  is a proportional constant) when the fluid is under critical conditions, a fluid's flow rate  $Q$  computed by the aforementioned No.2 fluid computation circuit when the fluid is under critical conditions and a fluid's flow rate  $Q'$  corrected from the flow rate correction computation circuit when the fluid is under non-critical conditions are inputted respectively to the aforementioned flow rate computation circuit.